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February 25, 1999

Magalie Roman Salas
Secretary
Federal Communications Commission
Room 222
1919 M Street, N.W.
Washington, D.C. 20554

Re: Revision of the Commission's Rules To Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, RM-8143

Dear Ms. Salas:

Please find enclosed an original and Five (5) copies of SnapTrack, Inc.'s comments regarding the above proceeding. Also enclosed is a "Receipt" stamped copy to be date-stamped and returned with the messenger.

Please do not hesitate to contact me at (202) 955-6300 with any questions regarding this filing.

Sincerely yours,

Kenneth R. Boley

Counsel for SnapTrack, Inc.

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C.

In the Matter of	)	
	)	
Revision of the Commission's Rules To Ensure Compatibility with Enhanced 911 Emergency Calling Systems	))))	CC Docket No. 94-102 RM-8143
	)	
Requests for Waivers of Section 20.18(e) of the Commission's Rules	)))	DA 98-2631

To: Chief, Wireless Telecommunications Bureau

MOTION OF SNAPTRACK, INC.
FOR LEAVE TO FILE COMMENTS OUT-OF-TIME

Pursuant to Section 1.46 of the Commission's Rules, 47 C.F.R. § 1.46, SnapTrack, Inc. ("SnapTrack"), by its attorneys, respectfully submits this motion to file comments in this proceeding out-of-time. Delays in obtaining copies of the waivers and comments of record in this docket from the Commission's document contractor, coupled with a family illness for SnapTrack's lead counsel, prevented SnapTrack from completing its response by the February 22, 1999, due date established in the Bureau's December 24, 1998 Public Notice.

Because these comments are filed in the last of a three-round pleading cycle, no party will be prejudiced by this brief and unavoidable delay. The Bureau's inclusion of the comments in the record is in the public interest, will not harm other parties and will provide input that will allow the Bureau to more completely examine the issues raised in its Public Notice.

WHEREFORE, this motion should be granted because the inclusion of the comments in the record is in the public interest and will not prejudice interested parties.

Respectfully submitted,

SNAPTRACK, INC.

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Dated: February 25, 1998

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To: Chief, Wireless Telecommunications Bureau

COMMENTS OF SNAPTRACK, INC.

Pursuant to the Public Notice issued by the Wireless Telecommunications Bureau on December 24, 1998 ("Public Notice"), SnapTrack, Inc. ("SnapTrack"), by its attorneys, submits these comments regarding the Bureau's guidelines for petitions for waiver of Section 20.18(e) of the Commission's E911 rule to permit carriers to consider the option of a handset-based approach to Phase II Automatic Location Identification ("ALI") requirements.

INTRODUCTION AND SUMMARY

By issuing the Public Notice, the Bureau has recognized that it is inappropriate for government to select technological winners and losers. The best mechanism for choosing the most effective, efficient ALI technology is the marketplace—in order for the market to work, there must be choices. Under the current regulatory standard, there is no choice, and the market therefore cannot work.

The culprit responsible for this anticompetitive arrangement is none other than technological innovation itself. When the Commission adopted its "Phase II" rule in CC Docket No. 94-102 in 1996, it was widely believed that only a technology implemented in the network would be capable of providing Phase II ALI. The standard adopted in the rule, therefore, did not consider any other type of solution. Accordingly, the Phase II rule does not permit the "phased-in" deployment that a handset-based solution requires; rather, the regulation contemplates "flash-cut" implementation no later than October 1, 2001 for Phase II ALI. 47 C.F.R. § 20.18(e). By prohibiting phased deployment, the rule not only presumed that the technology will be based in the network, but also inadvertently *ensured* that a network solution is the only option by which carriers may achieve regulatory compliance.

America's wireless consumers and carriers need not be limited to yesterday's technology solely because the rule was overtaken by subsequent technological development. As Bureau Chief Thomas Sugrue testified before the House Telecommunications Subcommittee on February 3, 1999, the Commission's Phase II rule is not technologically or competitively neutral.[1] The Public Notice therefore appropriately recognizes that alternative standards permitting phased implementation can serve the public interest in locating wireless 911 callers at least as well as (and perhaps better than) the current Section 20.18(e) standard.

[1] Testimony of Thomas J. Sugrue, Chief, Wireless Telecommunications Bureau, Federal Communications Commission, before the Subcommittee on Telecommunications, Trade, and Consumer Protection, Committee on Commerce, U.S. House of Representatives (Feb. 3, 1999) at 3; *see also,* Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, Memorandum Opinion and Order, *recon.*, 12 FCC Rcd 22665 (1997), ¶ 124.

If a carrier meeting an alternative standard allowing phased implementation will serve the interest of public safety at least as well as a carrier meeting the current regulation, then the Commission should grant a waiver—or modify the rule itself—based on that alternative standard, and let the marketplace work. The relative strengths and weaknesses of network-based solutions and handset-based solutions—including accuracy, cost, and performance—will and should be determined by carriers and consumers in the marketplace, not regulatory fiat, notwithstanding the strident opposition in this docket by network vendors who are competitively advantaged under the current system.

Indeed, the clear weight of the comments submitted on the Bureau's Public Notice demonstrate that neither handset-based technology nor network-based technology presents the *perfect* ALI solution. Each group of technologies has its own strengths and weaknesses. However, forwarding the cause of public safety requires the Bureau only to consider the relative strengths and weaknesses of the *current and proposed standards*. In the end, it will be the carrier's responsibility to meet either the standard established in the Phase II rule or the standard provided in any waivers. Whatever technology the carrier selects, the carrier will have to meet a clear, technologically neutral standard, and public safety will be served.

Nevertheless, the Bureau makes plain in the Public Notice that it wishes to build a record regarding the capabilities of a handset-based solution. Although much information already has been provided by carriers in comments and waiver requests in this proceeding, SnapTrack finds it necessary to respond to the misinformation provided to the Bureau by the companies promoting their own network solutions. Obviously, these companies are threatened by the prospect of waivers. In the absence of waivers, network-based technology possesses a federally-created monopoly. Recognizing that the marketplace, given a chance to work, will in many instances favor a handset-based solution, vendors of network-based technology understandably oppose waivers. Although they affect the language of public safety, their aim is clear: to eliminate competition by protecting the regulatory monopoly status of their technology.

As is more fully developed below, SnapTrack believes that the public interest will be served if the Bureau grants waivers considering a carrier in compliance with the Commission's Phase II requirements if the carrier meets the following standard:

(1) Achieve location accuracy of 90 meters using circular error probability ("CEP") methodology;

(2) Begin to deploy location-capable handsets by January 1, 2001; and

(3) Deploy only location-capable handsets after December 31, 2001.

SnapTrack applauds the Bureau's efforts to bring choice to the Phase II technology marketplace. In particular, SnapTrack congratulates the Bureau for recognizing that prompt resolution of the question of waivers and/or a modification of the Section 20.18(e) rule will help carriers deploy ALI technology well in advance of the October 1, 2001 deadline. The Public Notice, followed quickly by decisive action to allow handset-based technologies to compete in the marketplace, will best serve the interest of public safety.

I. GRANTING PHASE II WAIVERS UNDER THE CONDITIONS OUTLINED IN THE PUBLIC NOTICE IS MANIFESTLY IN THE PUBLIC INTEREST

In determining whether it is in the public interest to permit carriers to comply with Phase II requirements by meeting an alternative, phased deployment standard, the Bureau first must assess the extent to which public safety will benefit under the current rule. Such an inquiry must begin with this bedrock question: Will carriers be able to meet the current regulatory standard, whatever technology they choose?

There is no certainty that any technology will enable carriers to meet current Phase II requirements. As noted below, network-based technologies have not been proven to perform adequately in all environments and with all air interfaces. Furthermore, carriers harbor serious doubts about the technical and financial viability of network-based solutions.[2]

In short, there is no certainty that the deployment of Phase II technology on October 1, 2001, will be any more successful than the deployment of Phase I technology today. This uncertainty weighs all the more heavily in favor of granting waivers to ensure that the maximum number of technologies have the opportunity to compete in the Phase II marketplace.

A decision on whether to grant waivers and what alternative standards they should contain does not require the Bureau to make a technological choice. In fact, such an approach would be antithetical to the goal of technological neutrality. The best course for the Bureau and the Commission is to rely on the marketplace to weed out any Phase II solutions which are not technologically or economically viable.

In the final analysis, the public interest will be served if the Bureau grants waivers that include standard criteria similar to those proposed in the carriers' filings.[3] If the waivers require initial deployment of location-capable handsets in advance of the October 1, 2001 deadline, the

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[2] *See, e.g.* Waiver Request of Sprint Spectrum L.P. at 3; Comments of Wireless Services, Inc. at 2-3 (noting inability of network solution to work in TDMA network).

[3] Even SigmaOne, a network solution vendor, recognized that imposing conditions on waiver recipients would "ensure that carriers seeking to promote public safety by adopting a handset approach do just that—promote the public safety." Opposition of SigmaOne Communications Corp. at 9.

public will benefit because Phase II ALI will have to be made available to subscribers using those new handsets *before* it would otherwise be required under the current rule. In fact, the concern that granting waivers might somehow permit carriers to delay taking action toward achieving Phase II is completely unfounded. Carriers implementing handset-based ALI technologies under such a standard would actually have to *begin earlier* to provide location data to Public Safety Answering Points ("PSAPs") than would carriers implementing network-based technologies under the standard in the current rule. It is therefore not surprising that no commenter objected to requiring earlier deployment as a condition of Phase II waivers, and several carriers indicated their belief that early deployment would be feasible.

As SnapTrack's earlier submissions in this docket demonstrate, at expected rates of handset turnover a handset-based ALI solution will, within three years of initial deployment, achieve a higher rate of successful locations than is currently required by the Commission's regulations.[4] The earlier initial deployment occurs, the sooner that performance threshold will be achieved. In order to better ensure that handset turnover meets these projections, the Bureau should request that carriers using waivers specify the promotional plans they would use to achieve penetration.

Just as early deployment provides a public benefit, so, too, does a stricter accuracy standard. Again, no party has opposed the suggestion that carriers should meet improved accuracy requirements as a condition of Phase II waivers. Indeed, the public safety organizations certainly would like to achieve accuracy far superior to that currently required in the regulation.[5] Because

[4] *Ex Parte* Presentation of SnapTrack, Inc. to the FCC, CC Docket 94-102 (Oct. 30, 1998) ("SnapTrack Ex Parte").

[5] Public Safety Associations' Comments at 2 (noting support for a 40-foot or 10-meter accuracy goal).

of the tremendous expenditure network-based solutions are likely to require in order to achieve acceptable accuracy in areas that currently have only light cell coverage, handset-based solutions may well provide the only economically viable means for small carriers to meet even the accuracy standard in the rule, much less any improved accuracy under a waiver.[6]

II. ADDRESSING THE CRITERIA IN THE PUBLIC NOTICE

The Public Notice requests carriers seeking waivers to provide information in each of four general areas. As the Bureau notes, "[t]his information will assist us in assessing whether a particular waiver is likely to meet the Commission's objective of being technologically and competitively neutral with respect to enforcement compliance with its Phase II rules, while promoting the deployment of wireless E911 in an efficient and effective manner."[7] Accordingly, SnapTrack here addresses each of these areas, referencing material already in the record and providing new information where needed.

A. Accuracy and Reliability of ALI Technologies

The Public Notice seeks information regarding "the level of ALI accuracy and reliability the carrier plans to offer with its ALI technologies."[8] Given that few if any carriers have decided what technologies they will adopt for ALI, this request is necessarily indifferent to whether the carrier will select a network-based or handset-based solution.

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[6] *See* TruePosition, Inc. Response at 8, n.18 (noting that "carriers with sparsely located cell sites may have additional difficulties in providing Phase II E911.")

[7] Public Notice at 4.

[8] *Id.*

SnapTrack has already filed extremely detailed accuracy and performance data in the public record in this docket, and incorporates that information here by reference.[9] As that material demonstrates, SnapTrack's technology, which relies upon the Global Positioning System ("GPS"), provides accuracy and reliability that is far superior to that required in the Commission's rule. Furthermore, while the rule itself does not specify performance criteria in the discrete environments listed in the Public Notice, SnapTrack's technology has proven that it performs well in them all.[10] SnapTrack proposes that the Bureau require carriers using waivers to locate callers to within 90 meters using circular error probability ("CEP") methodology.

SnapTrack has no data regarding the performance of other ALI solutions, whether handset-based or network-based. However, to the extent that the Bureau undertakes to compare any technologies, SnapTrack urges the Bureau to adopt a "show me" approach in its evaluation. Specifically, while many of the vendors of network-based solutions are quick to sing the praises of their own particular products, the absence of solid test results for their products certainly casts a pall of suspicion over their claims. SnapTrack's performance is excellent, and SnapTrack has provided the data to prove it. The same cannot be said of those commenters who are endeavoring to keep handset-based technologies out of the Phase II market.

B. Rate of Deployment for Location-Enabled Handsets

The Public Notice observes that one "way in which the goals of the rules might be achieved would be if the carrier began implementation of ALI capabilities before the October 1,

[9] SnapTrack Ex Parte.

[10] *Id.*

2001, deadline, by offering ALI capable handsets to customers at an earlier date, and offering only ALI capable handsets no later than the date when all conditions for Phase II requirements are met."[11] Accordingly, the Bureau seeks information on the rate at which handsets capable of being located by a handset-based ALI solution can be deployed.

SnapTrack has previously submitted this information in the public record in this docket.[12] As those filings indicate, SnapTrack believes that if the Bureau provides waivers quickly enough, carriers selecting a handset-based solution will be able initially to offer location-capable handsets by January 1, 2001, and will be able to offer only location-capable handsets after December 31, 2001.

C. Minimizing Problems Associated with Non-ALI Capable Handsets

The Public Notice also requests carriers applying for waivers to provide "an analysis of estimated cost of upgrading or replacing existing handsets based on the options explored by the carrier" in an effort to "minimiz[e] problems associated with non-ALI capable handsets."[13] While only a few carriers have attempted to give any indication at all of the potential costs of "changing out" handsets, most seem to be in agreement that the cost of such an effort would be prohibitive.

SnapTrack believes that, at this early stage, the costs associated with proactive handset "change out" cannot be reasonably estimated. Carriers cannot now know the quantity of

[11] Public Notice at 3.

[12] SnapTrack Ex Parte

[13] Public Notice at 4.

handsets they will have to replace. Furthermore, because virtually all subscribers will give up their old handset for a new one in due course anyway, the cost incurred by the carrier is really only the cost of accelerating that upgrade by an unknowable period of time. To make matters even more complex, when a subscriber upgrades in due course to a new handset, carriers will undoubtedly subsidize that new handset retail price at some level. Thus, the additional cost of replacing non-location-capable handsets is impossible to predict.

Any estimate today of the incremental cost to a carrier of "changing out" its non-ALI handsets must therefore be based on speculation. Carriers are undoubtedly correct, however, that a rule requiring the mandatory replacement of older handsets as a condition of Phase II waivers would impose substantial and likely prohibitive costs on carriers. The marketplace will weigh the uncertainty of change-out costs as an integral component of decisions carriers make regarding their Phase II technology choices. The Bureau should not compound that uncertainty by imposing intrusive handset replacement requirements that lead to substantially accelerated equipment costs for carriers, and ultimately for consumers as well.

D. Locating Roamers

The Public Notice requests carriers to describe their plans to address "roamer situations."[14] The roamers the Bureau is concerned with are not those subscribers roaming to a territory served by a network-based ALI solution, because those roamers will be located just as effectively as those subscribers native to the territory, regardless of the location-capability of the roamers' handsets.

As for users with location-capable handsets roaming in a territory served by a different handset-based ALI technology, they, too, will be located by the host carrier. Standardization efforts by the standard-setting bodies for each of the air interfaces will ensure interoperability between GPS-based handset solutions.[15] These standardization activities will mitigate, and eventually eliminate, any residual concern about the impact of non-network ALI approaches on roaming subscribers.

It is only when a subscriber without a location-capable handset roams to a territory served by a handset-based ALI solution that any "roamer situation" may exist. Yet any such problems will, by operation of simple market economics, disappear over time. As handset manufacturers receive more orders for location-capable handsets, they will take advantage of the economies of scale inherent in mass production and will build only location-capable handsets, regardless of the ALI solution adopted by the carrier of the ultimate retail purchaser. Therefore, as subscribers upgrade to new handsets, the number of non-location-capable handsets in use will decline until they are virtually extinct. As a result, the "roamer situation" associated with non-location-capable handsets will disappear. In addition, even if a roamer cannot be located to Phase II specifications, the carrier will be able to provide the PSAP with Phase I-level location information.

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[14] *Id.*

[15] Development of interoperability standards for handset-based ALI technologies has now been completed for CDMA systems, and development is underway for other air interfaces. *See,* Comments and Petition for Waiver of AirTouch Communications, Inc., Attachment 2 (providing a letter from Phil Brown, Chair, Working Group I, TIA TR-45.5 Subcommittee, to Kim Chang, Vice-Chair, Working Group II, TIA TR-45.5 Subcommittee (Nov. 18, 1998) ("the membership of WG-I feels baseline text for the standardized interoperable approach must be complete by the end of the February, 1999 meeting")).

Perhaps more importantly, as a policy matter there is nothing about roamers that is unique to handset-based ALI technologies. Despite the short-lived nature of any "roamer situations," the Phase II standard in the Commission's current rule allows shortfalls in performance, as long as the carrier achieves overall statistical compliance with the standard (essentially 67% locational accuracy to 125 meters). For example, it is well known that network solutions do not perform well in rural, "light" urban, or other locations where there are not multiple cells overlapping. However, a carrier using a network-based ALI technology may comply with the rule if the number of 911 calls from these areas is low enough and if the performance of the location technology is good enough in areas with strong cell coverage. In other words, *the current standard permits ALI solutions to make up for poor performance in locating some subscribers by improved performance in locating others.* This flexibility is inherent in the nature of a general statistical performance standard. Allowing such flexibility for network-based ALI solutions in the current rule and denying it to handset-based ALI solutions under an alternative standard designed to offer carriers another choice of ALI technologies would be both discriminatory and self-defeating, because it would prevent the very technological neutrality that is the Bureau's goal in the Public Notice.

III. SETTING THE RECORD STRAIGHT ON THE STATUS AND CAPABILITIES OF HANDSET-BASED ALI TECHNOLOGY

Several vendors of network-based ALI systems argue strenuously that the Commission should not grant the requested waivers, claiming that deployment and performance of handset-based solutions are so uncertain that no waiver can or should be granted. These argumentative filings seriously misstate the facts in order to advance a proprietary commercial interest in maintaining the current, discriminatory Phase II standard.

There are three ways that all of the network-based solution vendors' comments are fundamentally flawed. First, they have mischaracterized the state of the development of handset-based ALI systems. Second, they have failed to apprise the Commission of the substantial uncertainties still facing network-based systems. Finally, they do not address, let alone explain, why uncertainties about handset-based systems should justify denying the waivers and leave carriers with only a choice among network-based systems, which possess their own uncertainties about deployment and performance. While such a result might be in the network vendors' interests, it cannot be in the public interest to forego the performance benefits flowing from meeting the waiver conditions.

A. Handset Based ALI Systems Are High Performance and Well-Positioned for Early Deployment

Network vendors repeatedly maintain that handset-based systems will not be ready until 2002 or later,[16] that they will not work in many environments,[17] or that they will not work accurately.[18] All of these assertions are demonstrably wrong.

The network vendors claim GPS location devices are inherently limited, and then cite that claim as support for a conclusion that no handset-based solution can be accurate. SnapTrack's

[16] *See* TruePosition Response at 19.

[17] Comments of Cell-Loc at 4-6.

[18] KSI Reply at 10.

own test results, previously filed in this proceeding,[19] explicitly point out the sharp contrast between the results of a standard GPS receiver and SnapTrack's network-assisted GPS system in the very environments where TruePosition claims a handset-based system will not work.[20] As the summary results from SnapTrack's Denver tests show, network-assisted GPS can have remarkable results in indoor and urban canyon environments where a conventional GPS receiver cannot work.[21] Thus, because they ignore the very technological developments on which the Public Notice seeks comment, claims by network proponents that GPS-based solutions are impractical are simply incorrect.

The network vendors are also wrong when they claim handset solutions will not be available until 2002 or later. Just this week QUALCOMM, one of the largest CDMA handset and component vendors, announced that its next generation of ASIC would allow for handset-based ALI, and would be available in test quantities later this year.[22] Thus the prospects for early availability of ALI-equipped handsets are very good. Similarly, as several carriers have noted, the development of standards is well along, and vendors are not waiting for these standards to become final to make their own plans for deployment. Assuming that ALI-equipped handsets are available by late in 2000, at least one carrier estimates that over one-third of its customers will

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[19] *See, e.g.,* Powertel Petition for Waiver, Exhibit A.

[20] TruePosition Response at 13.

[21] Another example of this difference in performance is provided in Exhibit A. This attachment is SnapTrack's contribution to the T1P1 Committee which received the Motorola analysis referenced at n. 28 of TruePosition's Response.

[22] The full text of three QUALCOMM press releases is provided as Attachment B to these comments.

have such handsets by the end of 2001, and more than 90% will be ALI capable within three more years.[23]

B. Network-Based Systems Still Face Many Uncertainties in Deployment and Implementation

The network vendors conveniently fail to note the many uncertainties associated with the deployment and use of their own systems. However, such uncertainties should be taken into account as the Commission considers the "but for" world that will exist if waivers are not granted. These uncertainties result from the fact that network systems have apparently not yet been deployed, or even developed, in systems using GSM or CDMA air interfaces.[24] Since nearly every PCS system uses one of these technologies, there apparently is no assurance that a network-based solution is even feasible for these systems. As a result, not only users roaming into such systems, but also native subscribers, may not be located to Phase II standards by PCS carriers using network technologies.

Additional uncertainties result from the fact that many carriers seem to believe they will not be able to afford a network-based solution. The substantially higher costs associated with network-based ALI technologies—even apart from problems associated with the need to construct many more cell sites in order to triangulate subscribers—have been well-documented in the

[23] AirTouch Communications, Inc. Comments and Petition for Waiver at Attachment 1.

[24] AT&T also notes that "despite the claims of some equipment manufacturers to the contrary, there is currently no *network-based* solution available for carriers using Time Division Multiple Access ('TDMA') technology in their wireless networks." Comments of AT&T Wireless Services, Inc. at 2-3 (emphasis in original).

comments.[25] Once again, in systems lacking the financial wherewithal to deploy a network-based system, neither roamers nor subscribers would be located.

Finally, with only a network-based solution available, the Commission will have to rely on some future technological development to accurately locate subscribers (or roamers) in sparsely covered areas where only one or two cell sites are available to the customer, or in dense urban canyons where multipath interference makes network solutions infeasible. By failing to recognize these inherent limitations of network-based technologies, the network proponents have provided the Commission with a biased view of the relative merits of different ALI approaches.

C. Implementation Uncertainties Are Not a Valid Reason to Maintain Technologically Discriminatory Phase II ALI Standards

The proponents of network ALI technologies do not address, let alone explain, why uncertainties about handset-based systems should justify denying waivers and leaving carriers with only a choice among network-based systems. There is no doubt that network technologies face substantial cost, interface and deployment challenges. These uncertainties make it unclear whether network-based ALI technologies can eventually be adapted to meet the needs of digital PCS networks, as well as whether network technologies can meet even the current Phase II location standard in rural and other environments.

That is not a valid public policy reason to deny carriers, and consumers, the potential benefits of handset-based solutions. Both approaches to ALI implementation face questions re-

[25] *See, e.g.,* New Mexico RSA 6-III Partnership at 2 (estimating $6 million cost of network solution build-out), Texas RSA 7B3, Inc. Request for Waiver at 2 (estimating $1.2 million cost of building additional cell sites for network solution), Advantage Cellular Systems, Inc. Request for Waiver at 2 (estimating $7.5 million cost of building additional cell sites for network solution).

garding overall accuracy and deployment speed. While the uncertainties are different for each approach, the common thread is that the Commission's Phase II rules should permit carriers to deal with these predictive judgments in a technologically and competitively neutral manner. While the opposite result might be in the network-based technology vendors' narrow commercial interests, it cannot be in the public interest to forego the performance benefits flowing from implementation of ALI solutions under a revised waiver standard that neither dictates network technologies nor excludes handset-based approaches.

The public interest question for the Bureau and the Commission, then, is whether a waiver setting conditions that make a handset-based solution feasible will enlarge or reduce those uncertainties. SnapTrack submits that the only possible result of such a waiver would be to improve the likelihood that the Commission's public interest goals are met. By granting the waivers and achieving technological neutrality, the Bureau will be relying on marketplace forces to decide questions about the suitability of one solution or another. Even if no carrier ever took advantage of the waiver to adopt a handset solution, the mere existence of the option can be expected to spur development of network solutions. And, of course, if no carrier ever takes advantage of the waiver, the waiver would not have led to any delays in implementation.

On the other hand, if some carriers do use the waiver to pursue a handset solution, then subscribers of both handset-based and network-based technologies will benefit. Customers of carriers using network-based systems will be better off because the accelerating effect of a competitive alternative will have spurred improvements such as those that network vendors have recently announced. Customers with carriers adopting handset-based solutions will be better off because the proposed conditions for the waiver will assure that these carriers make ALI available earlier than the current deadline, locate 911 callers with more precision, and, in a short period, locate 911 callers with a higher degree of confidence than is required under the existing rules. Either way, the Commission, the public interest and consumers all benefit.

CONCLUSION

Granting Phase II waivers for carriers deploying handset-based solutions is necessary to achieve technological and competitive neutrality in the Commission's ALI rules. Modifying the Phase II standard to permit a phased deployment is in the public interest and will produce a net benefit for users of both network-based and handset-based solutions. For all these reasons, the Bureau should act promptly to grant carrier requests for waivers, upon conditions described here and in the Public Notice, in order to make ALI available earlier than the current deadline and to locate 911 callers with more accuracy than is required under the existing Phase II rule.

Respectfully submitted,

SNAPTRACK, INC.

By: ______________________

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Dated: February 25, 1998

A

TITLE: **SnapTrack Enhanced GPS Technology: Field Test Results Using Prototype GPS Handset Antenna, Including the Impact of User Head Blockage.**

SOURCE: SnapTrack, Inc.

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DATE: August 17, 1998

ABSTRACT: This contribution discusses the complexity of making accurate assessments of the issues pertaining to integrating a GPS antenna into cellular handsets. While the simplifying assumptions and direct antenna laboratory measurements made in a previous paper [1] provide a useful starting point for assessing antenna issues, the conclusions drawn in that contribution are overly pessimistic. More sophisticated antenna design considerations and advanced GPS processing algorithms can overcome much of the loss identified with conventional GPS antennas in handset applications. This assertion is substantiated by actual GPS location data collected using a handset mock-up, held against the head, in several difficult GPS propagation environments.

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1 Background

This contribution identifies some of the issues that distinguish a laboratory experiment from the "real-world" environment and discusses how these differences can influence GPS performance. Preliminary results of actual location finding experiments, utilizing a novel handset sized GPS antenna and a state-of-the-art GPS receiver in a handset sized box in proximity to a real human head, are presented to reinforce these differences.

Integrating GPS reception into cellular handsets for the purpose of location is technically challenging. Several GPS manufacturers have successfully addressed many of the issues pertaining to GPS performance in blocked or severe multipath environments with improvements in receiver sensitivity and sophisticated new processing algorithms. These improvements need to be coupled with an antenna implementation that maximizes location system performance.

A handset mounted GPS antenna design faces multiple constraints not encountered in more conventional GPS applications. These constraints include small form factor, successful operation in a variety of orientations, and successful operation in proximity to human bodies, conductive phone components, and other metallic objects such as automobile roofs.

Experiments detailed in a previous submission [1] were performed with conventional GPS antennas that were adapted to handset geometries. Direct radiation patterns were measured for antennas that were in proximity to the human body. Conclusions drawn in that submission paint a pessimistic picture of the feasibility of GPS in handsets. Such conclusions are not consistent with results of ongoing live satellite experiments being conducted by SnapTrack, Inc. Preliminary results from these ongoing field tests are presented in this contribution.

2 Limitations of Laboratory Measurement Model for Prediction of Real-world Performance

Krenz, et al., [1] provided a number of antenna measurements performed in an anechoic chamber. This study provided useful information on the effects of body blockage upon antennas employed by cell phones. Conclusions were then drawn based on extrapolating these laboratory measurements to predicted field performance in a GPS mobile location application. While the laboratory measurement method is quite important in developing antenna designs, it does not accurately predict the real world performance in complex multiple (GPS) signal multipath environments in which locations are to be performed. As will be shown, the performance of the SnapTrack location technology is substantially better than that predicted on the basis of anechoic chamber measurements.

2.1 Effect of Body Blockage on GPS Coverage

The data analysis approach used by the authors of the previous paper [1] consisted of averaging the antenna response over the entire hemisphere, including those portions of the hemisphere blocked by the human body. This averaged number was then used as representative of the specific antenna performance in a GPS application. While average upper hemisphere radiation efficiency is a good metric of antenna performance in some applications, including omnidirectional transmitters, it is not an ideal metric for antennas used in GPS reception. The average efficiency provides a measure of how well, on average, a signal to anywhere will be transmitted or received.

For a GPS receiver an appropriate measure is the probability that enough of the upper hemisphere has little attenuation, so that three satellites can be found. Thus, the RHCP Cumulative Distribution Function [1] is a more useful metric. However, to utilize this measure accurately, it must be recognized that the requirement is not that 87.5% of the sky be visible (which would be true if it were necessary to find all satellites above the horizon), but instead that enough of the sky be visible to find any 3 satellites. Although detailed calculations based upon orbital parameters can be performed, a rough estimate can be obtained by recognizing that at least 6 satellites are usually above the horizon, and distributed widely throughout the sky. Thus, to find three satellites, approximately ½ of the sky must be visible with acceptable attenuation. Utilizing Fig. 8 of [1], at least for the Patch antenna at the phantom's ear, the RHCP gain will exceed −4 dBiC, not the −14 dBiC cited. This loss level is well within the capability of the SnapTrack GPS receiver to overcome. This hypothesis is born out by the field test results discussed later in this paper.

2.2 Effect of Snapshot Signal Acquisition Methodology on Body Blockage

Unlike conventional GPS receivers which need to continuously monitor satellite signals over a sustained period of time, the SnapTrack GPS receiver can determine location based upon a "snapshot" of data collected over a brief period, typically 1 sec. For this receiver, body or head blockage becomes much less significant since the data can be collected while the user is dialing, when the cellular phone is held out in front of the user. This dialing position has much less body blockage than the talking position and thus greater sky visibility. In general, one would expect to perform location determinations only while either holding the phone out, or while conversing on it. Thus, GPS performance while clipped to the belt [1] is probably not a significant consideration.

2.3 Effect of Ground Bounce and Other Reflected Signals on GPS Performance

Advanced GPS receivers, including those available from SnapTrack, have not only high sensitivity, but also specialized algorithms for utilizing signals reflected from the ground, and other indirect and multipath signals, with modest degradation in accuracy. Thus, an analysis of GPS reception that is limited to direct signals in the upper hemisphere is not fully indicative of the ability of a GPS receiver to determine locations in a difficult environment.

The test approach of the previous contribution used an anechoic test chamber that eliminated the effect of ground bounce and other reflected signals [1]. In comprehensive, audited field testing programs, SnapTrack has confirmed that such reflected signals, when combined with a very high sensitivity receiver, are significant in supporting high accuracy position determination. In fact, in some cases, these may be the only available signals for location determination. Such reflected signals are particularly common to indoor and inside car environments. (These two environments are high probability usage locations for 911 and other location based applications.)

SnapTrack antenna testing results provide objectively measured field performance in typical mobile location environments. Substantial additional testing is required for different antenna configurations and different field environments, but these initial results clearly indicate the viability of using reflected signals.

2.4 Effect of Optimized GPS Handset Antenna Designs

A major challenge for antenna designers is to develop an antenna that maximizes performance and minimally impacts the handset form factor. While developing such an antenna may require a substantial engineering effort, the GPS antenna alternatives used in the prior study [1] do not adequately represent the range of performance that could be achieved with more optimized antenna designs. Selecting conventional GPS antennas and adapting them to a phone seriously degrades the antenna performance. A patch antenna with a reduced ground plane performs much worse than a patch antenna with a large ground plane [2]. The location of an end fed helix relative to other metallic objects in the phone has dramatic effects on the antenna performance [2]. Optimal performance of a GPS system in a handset can only be obtained with a well designed antenna that is an integral part of the handset design. Issues such as balanced vs. unbalanced feed, use of suitable dielectrics, and proximity of ground planes and other metallic objects within the handset must be considered as part of the antenna design process.

In contrast to the antennas used in the prior paper [1], the miniaturized helical antenna used for the field testing discussed in this paper has the potential for high performance in a small mechanical package more adaptable for integration into a handset. Additionally, there exists the potential for GPS antenna solutions that could be incorporated into a cell band or PCS band antenna. This combination could be another alternative to provide the needed GPS performance with a minimal impact on the handset package.

2.5 Commonality of Antenna Issues For GPS and Alternate Location Approaches

Location determination using GPS is based upon performing triangulation calculations on signals received from at least 3 satellites, out of the typically 6 or more satellites above the horizon. Thus, if one satellite is blocked by the user's body, another satellite may be visible in a different direction. Location determination based upon signals received from multiple cellular base stations faces similar issues. However, it would be rare that 6 base stations would be within range from which to select 3, and all cellular signals will be approximately horizontal (where blockage is worst for these terrestrial based systems). For GPS based systems, the portion of the sky directly overhead (the "up" direction) is very useable and would typically have less body blockage than the horizontal plane. Thus, the issues of head and body blockage of handset antenna coverage are at least as important for location alternatives which depend on the ability of a handset signal to be picked up by multiple base stations, or for a handset to receive emissions from several base stations. Therefore, SnapTrack believes that the issues related to operation in the presence of body blockage and poor orientation are common to any location method.

3 Test Methodology

3.1 Introduction

The tests described below are part of an ongoing evaluation program of prototype GPS antennas targeted as potential solutions for handset integration. The results presented are the initial findings and will be substantially augmented with additional testing as prototype helix antenna designs evolve. Importantly, even these preliminary results clearly confirm SnapTrack's assertion that the predictions of field performance made in a previous submission [1] are overly pessimistic relative to the real-world results.

SnapTrack has previously conducted extensive field testing of its GPS technology in a large variety of difficult environments, such as urban canyons, inside large structures and inside automobiles, using standard GPS antennas as a reference point. In some cases, the effect of head blockage was included. These field testing programs were defined and audited by wireless carriers or manufacturers, and were conducted in the San Francisco area, Denver, Tokyo and Kyoto.

Given the existing field test data described above, SnapTrack's handset GPS antenna testing program will focus on comparing results with handset antennas and head blockage with those results already achieved with standard GPS antennas. These real-world results will be combined with laboratory measurements to provide a complete picture of antenna performance.

3.2 Test Set-up and Procedure

All tests were done with a SnapTrack GPS receiver using a prototype miniaturized (10mm x 20mm) helix (Figure 1). The GPS receiver is packaged in a metalized box roughly the size of a handset. Tests were done in three environments typical of wireless handset usage. These environments were as follows:

1. Inside a two story office complex in a windowless room (Figures 2, 3 and 4)
2. Inside a car in a parking lot with partial tree blockage (Figures 5 and 6)
3. Outdoors in a parking lot surrounded by two story buildings with partial tree blockage (Figure 7)

The first two environments contain no unobstructed GPS signal paths. GPS location determinations done at these two sites typically use a combination of reflected and attenuated satellite signals. The third environment contains direct signal paths, ground bounce reflected signals and foliage attenuated signals.

In each test site two experiments were run:

- Thirty location attempts were made with the SnapTrack GPS receiver held away from the body in a "dialing" position
- Thirty location attempts were made with the SnapTrack GPS receiver held against the head in a "talking" position (Figures 4, 6 and 7)

Test results are presented in Charts 1 through 6. The information is organized as follows:

- For each 30 sample test a scatter plot is generated showing the horizontal location error in meters of each location attempt. Ground truth is shown at the 0,0 point in the center of the graph.

- The number of location attempts for this set of data (always 30) is shown in the inserted table
- The percent of successful locates for the 30 attempts. Note that the SnapTrack receiver was able to achieve 100% success rates for all three sites including the tests done with head blockage.

4 Test Results

4.1 *Inside Building Tests (Charts 1 and 2)*

All 30 of the location attempts for both no head blockage and head blockage cases yielded successful location determinations. Accuracy was below 25 meters for the no head blockage case and below 30 meters for the head blockage case. As expected, the scatter diagram for the no head blockage case (Chart 1) shows a tighter error cluster (and therefore better accuracy) than the head blockage case (Chart 2).

4.2 *Inside Car Tests (Charts 3 and 4)*

All 30 of the location attempts for both no head blockage and head blockage cases yielded successful location determinations. Accuracy was below 25 meters for the no head blockage case and below 30 meters for the head blockage case. The scatter diagram for the no head blockage case (Chart 3) again shows a tighter error cluster than the head blockage case (Chart 4).

4.3 *Outside, Under Tree Tests (Charts 5 and 6)*

All 30 of the location attempts for both no head blockage and head blockage cases yielded successful location determinations. Accuracy was below 15 meters for both cases. In these tests, the scatter diagrams for the no head blockage case (Chart 5) and the head blockage case (Chart 6) show similar error clusters. This similarity indicates a substantial ground bounce effect coupled with a sizeable number of direct satellite paths for both blockage cases. These conditions reduce the effect of the head blockage to the point that the location accuracy is similar for both cases.

4.4 *Test Results Summary*

The combination of the miniaturized helix antenna and the SnapTrack GPS receiver produced 100% successful location yields for all three test sites even under head blockage conditions. For the Inside Building and Inside Car test, head blockage reduced the resultant location accuracy by 20% (from sub 25 meters to sub 30 meters). However, even the head blockage cases yielded accuracy a factor of four better than the FCC mandate of 125 meters. For the Outside, Under Tree tests, head blockage had minimal effect of the resultant accuracy (sub 15 meters for both blockage cases) due to the presence of ground bounce signals and sufficient direct satellite paths. These results, while not yet exhaustive, clearly confirm the viability of a handset based GPS solution when an appropriate antenna design is coupled with a high sensitivity GPS receiver.

5 Conclusions

Design of GPS antennas for cellular handsets is a challenging issue. In a previous submission, basic laboratory experiments were performed by adapting free space GPS antennas to a handset geometry [1]. The conclusions drawn from these measurements gave excessively pessimistic predictions of the field performance of handset based GPS systems. This performance can be significantly improved by utilizing antennas designed specifically for handset geometries. A GPS receiver needs to find only 3 satellites *somewhere* in the sky, and coupled with advanced digital signal processing techniques can utilize not only direct signals, but indirect signals as well. Experiments with real-world data demonstrate that GPS can be used reliably for location in a handheld device, despite body blockage and other signal attenuating effects. Accurate locations were consistently determined when the receiver was held next to a human head in difficult environments such as indoors or inside an automobile.

References

1. Krenz, E., Efanov, A, and Birchler, M., *GPS Antenna Handset Integration Issues for Assisted GPS Positioning Method*, submitted to T1P1, 7/22/1998.

2. Fujimoto, K., and James, J., Mobile Antenna Systems Handbook, Artech House, 1994.

Chart 1: Inside Building - No Head Blockage

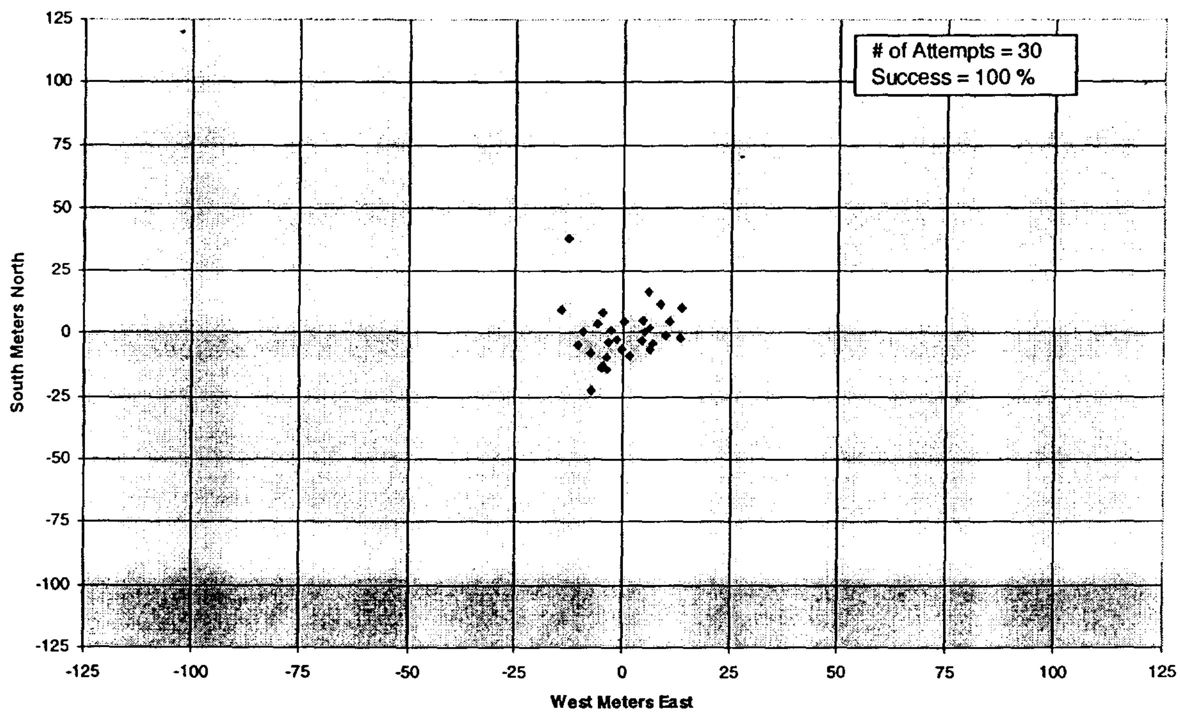


Chart 2: Inside Building - Head Blockage

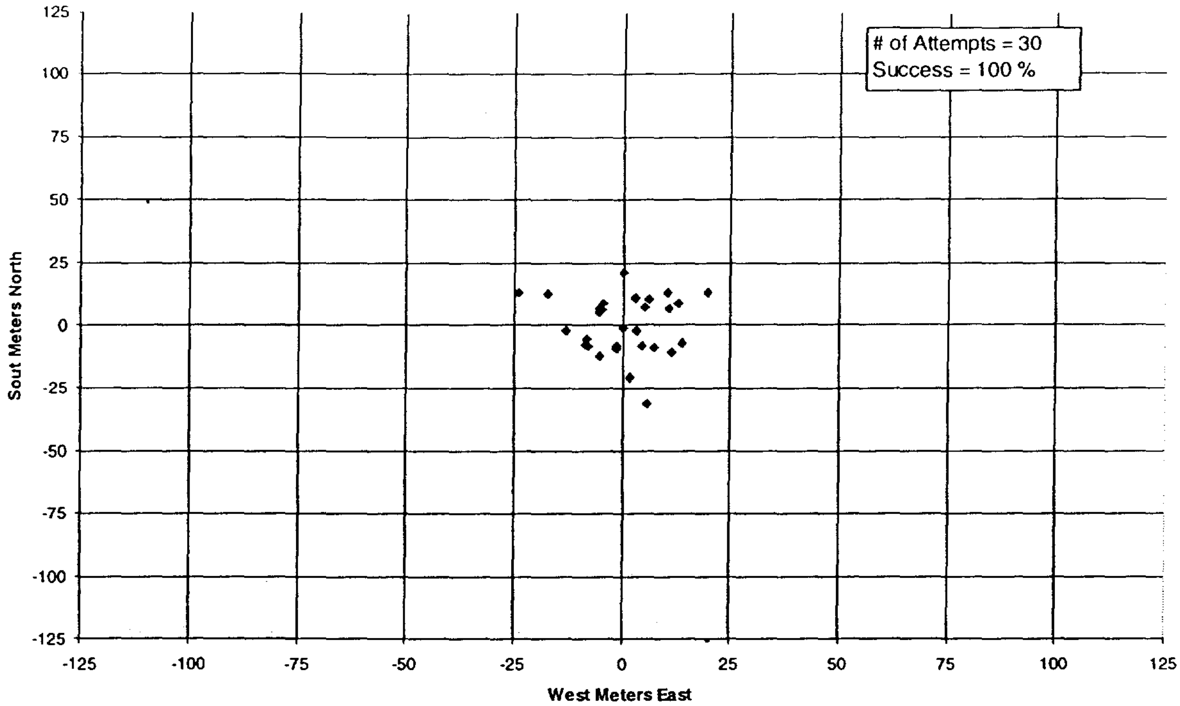


Chart 3: Inside Car - Under Tree, No Head Blockage

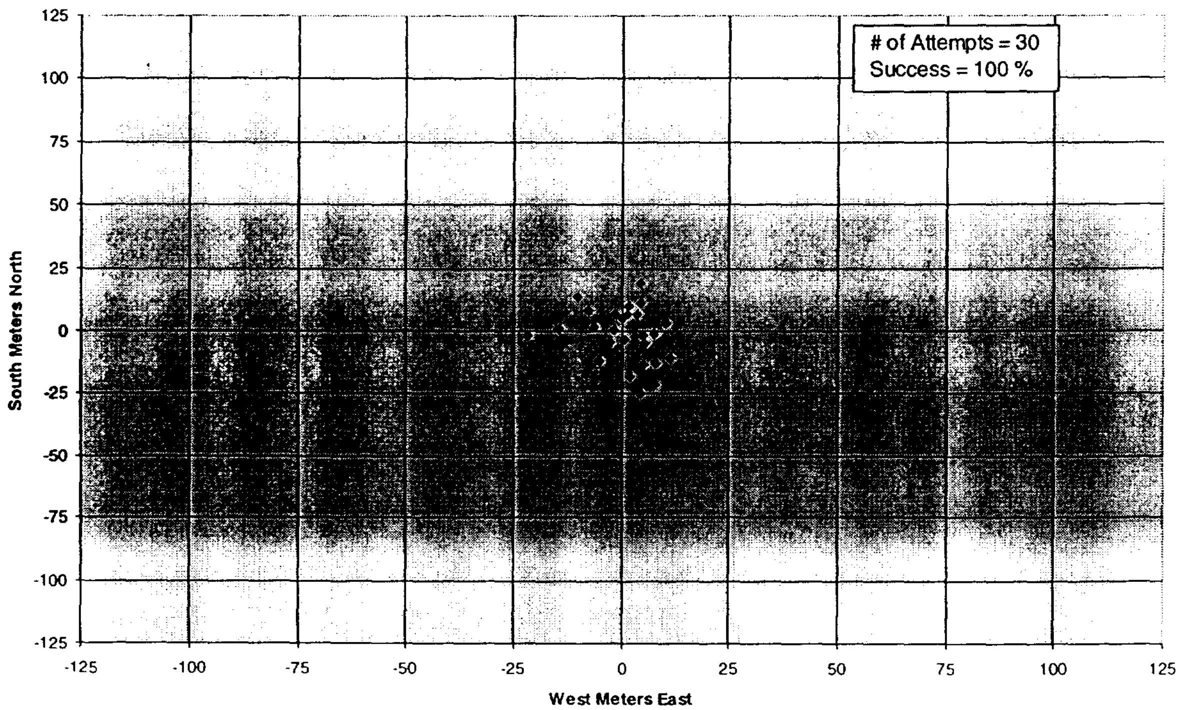


Chart 4: Inside Car - Under Tree, Head Blockage

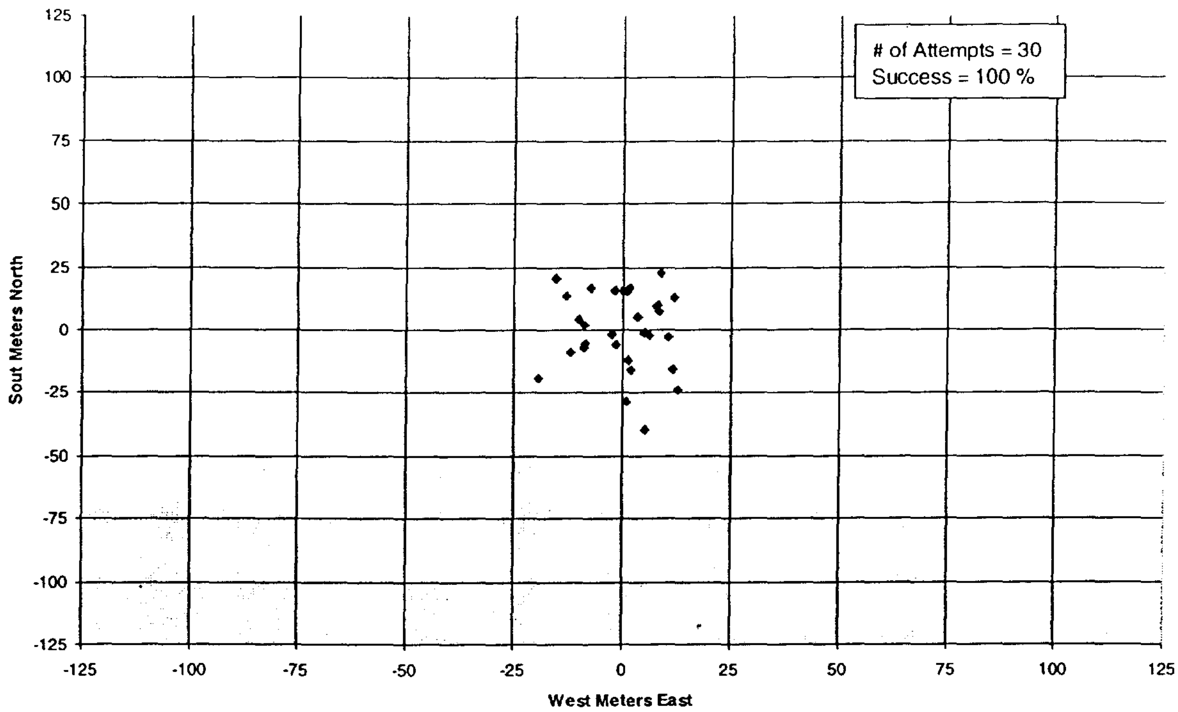


Chart 5: Outside - Under Tree, No Head Blockage

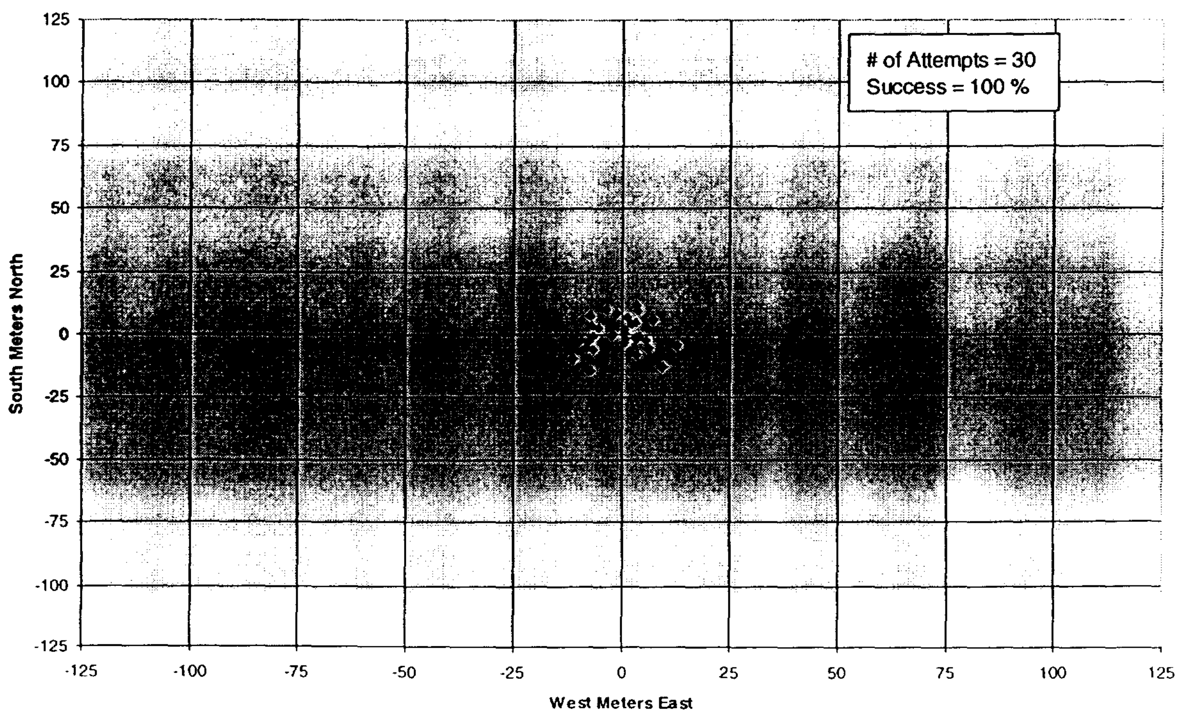
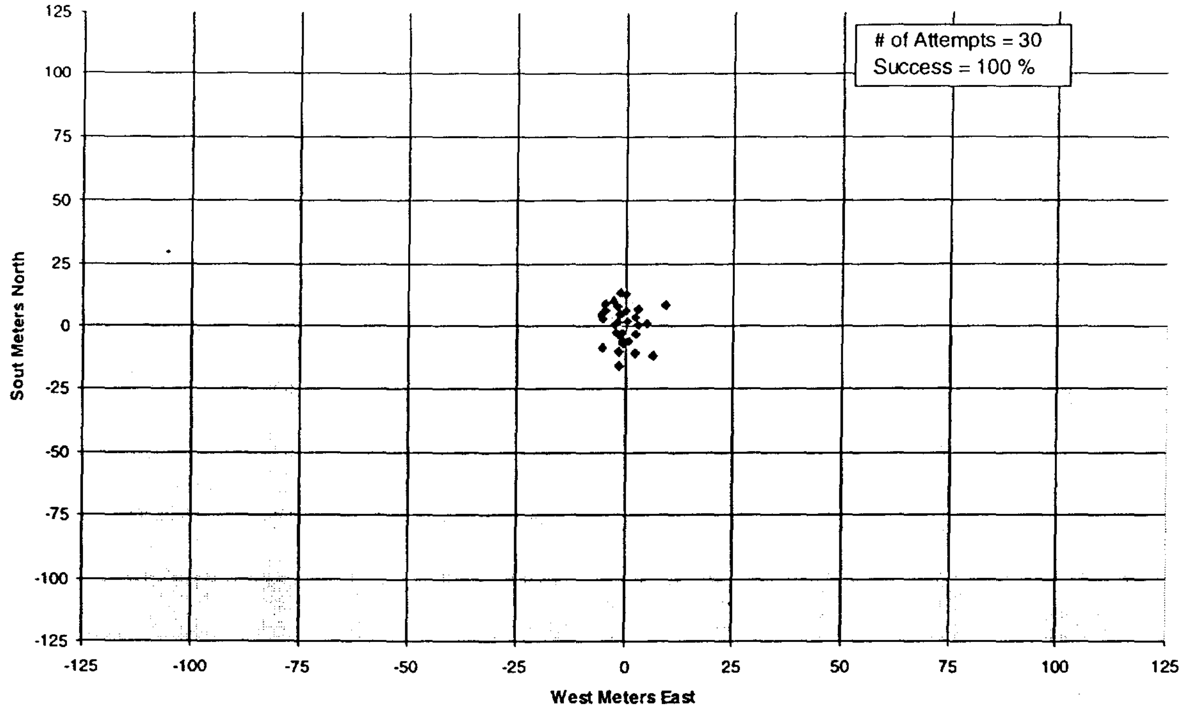


Chart 6: Outside - Under Tree, Head Blockage



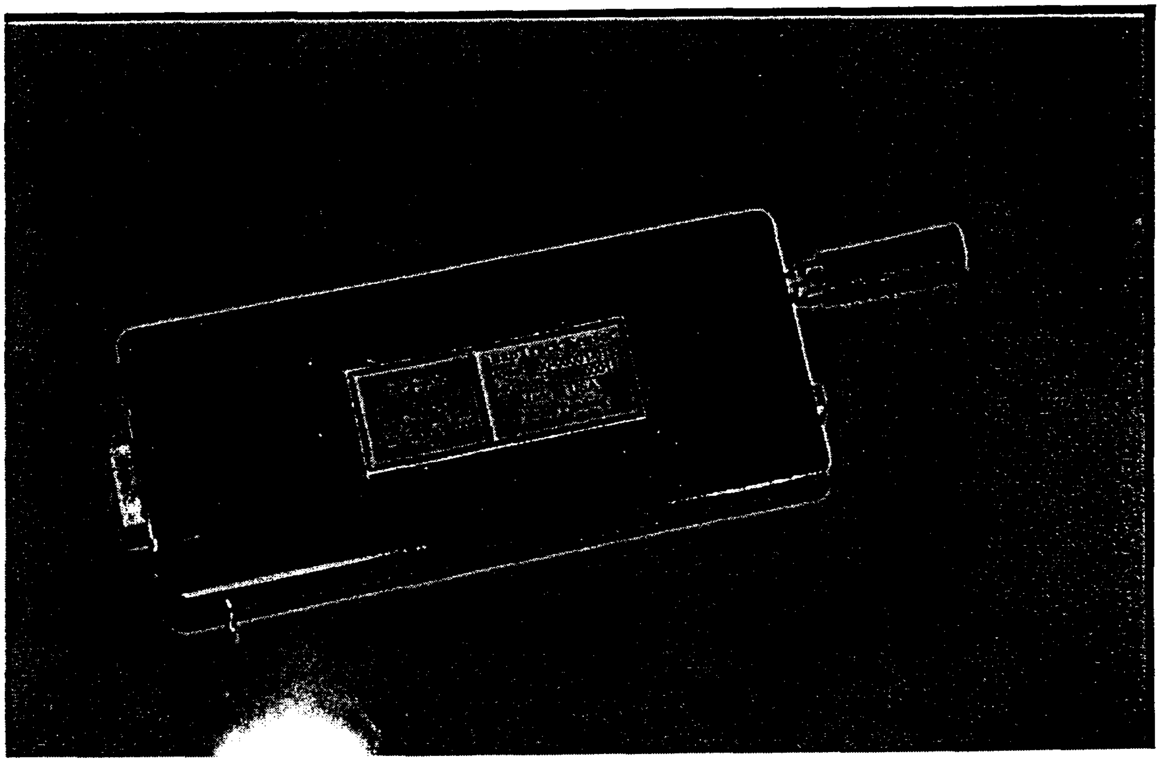


Figure 1. System Configuration – Miniature Helix Antenna Mounted On SnapTrack GPS Receiver

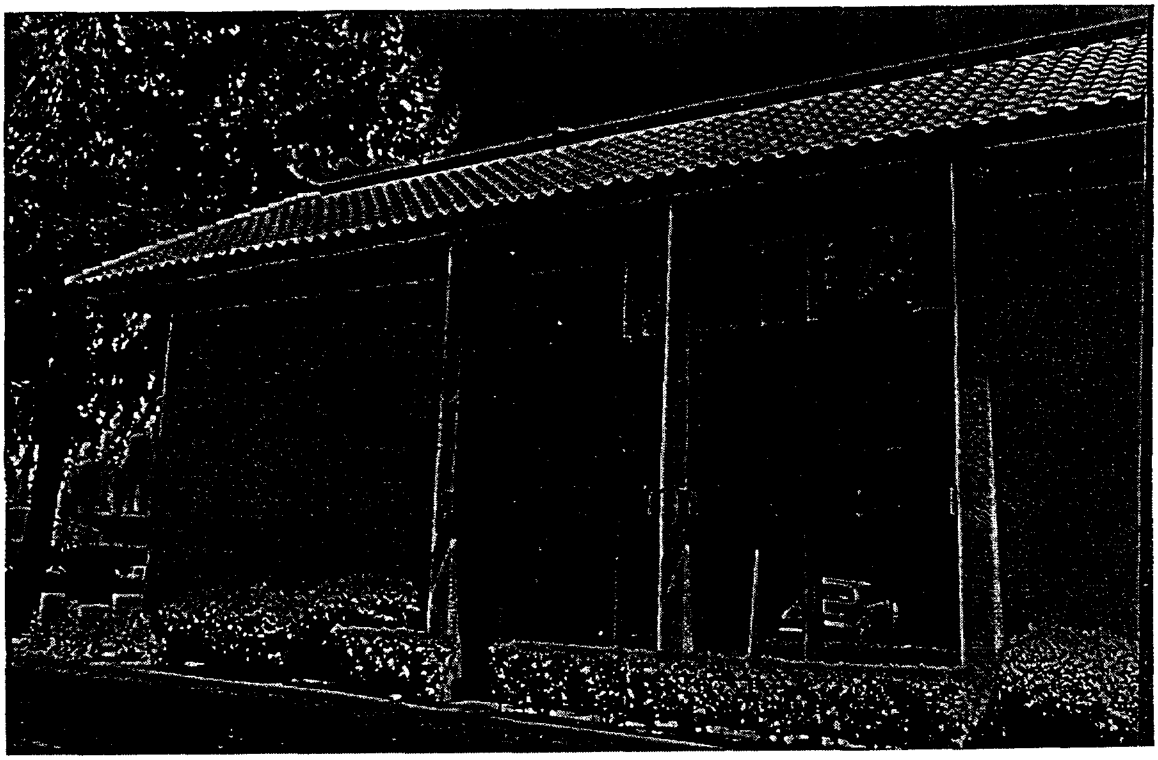


Figure 2. Test Location – Inside Building Test

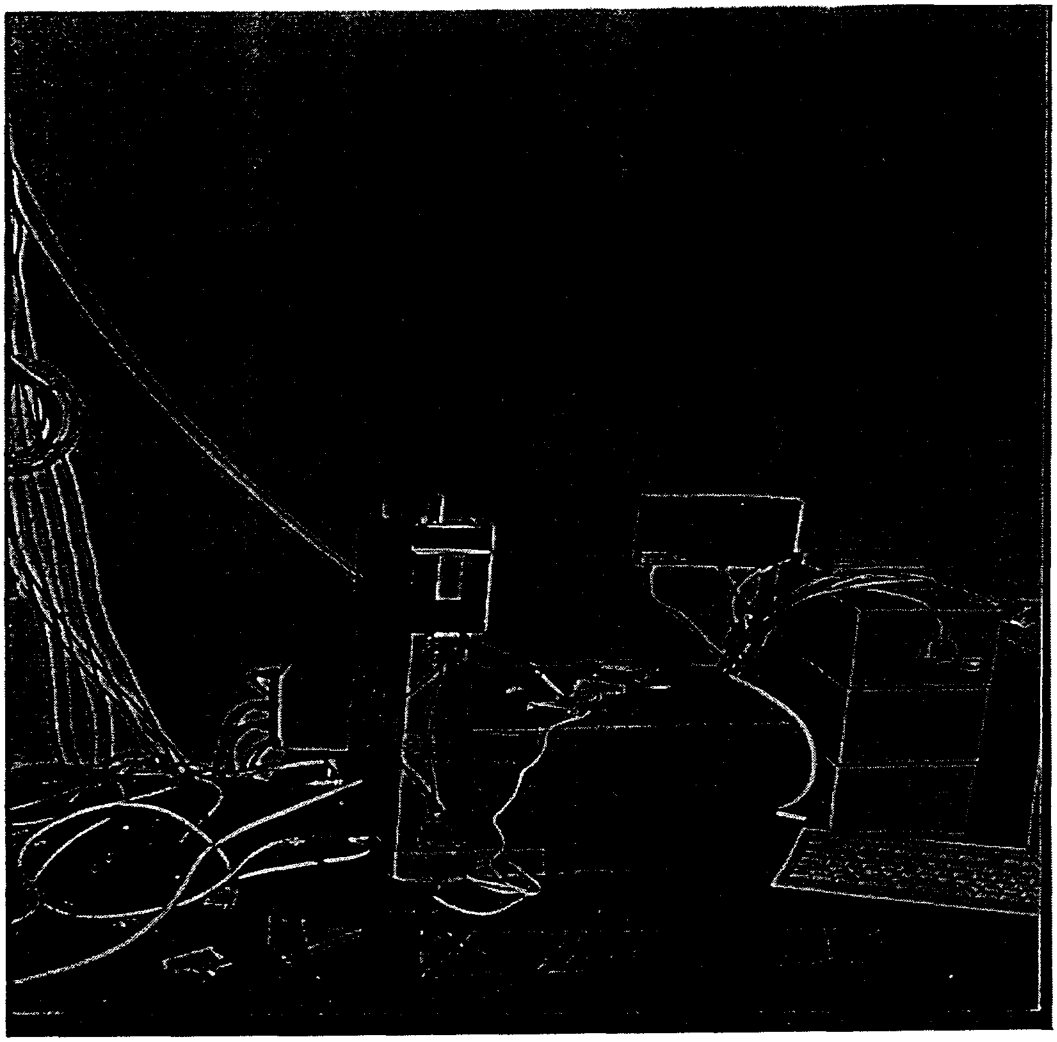


Figure 3. Test Configuration – Inside Building Test With No Head Blockage

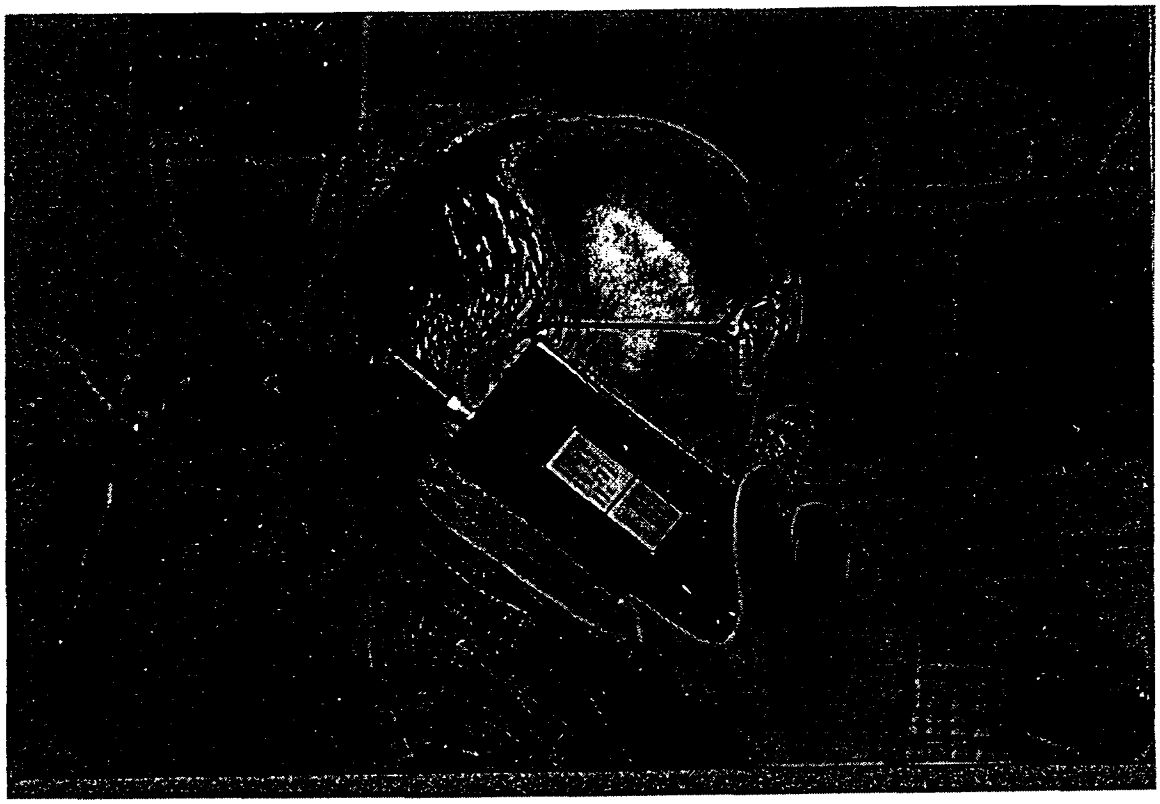


Figure 4. Test Configuration – Inside Building Test With Head Blockage

Figure 5. Test Location – Inside Car, Under Tree Test

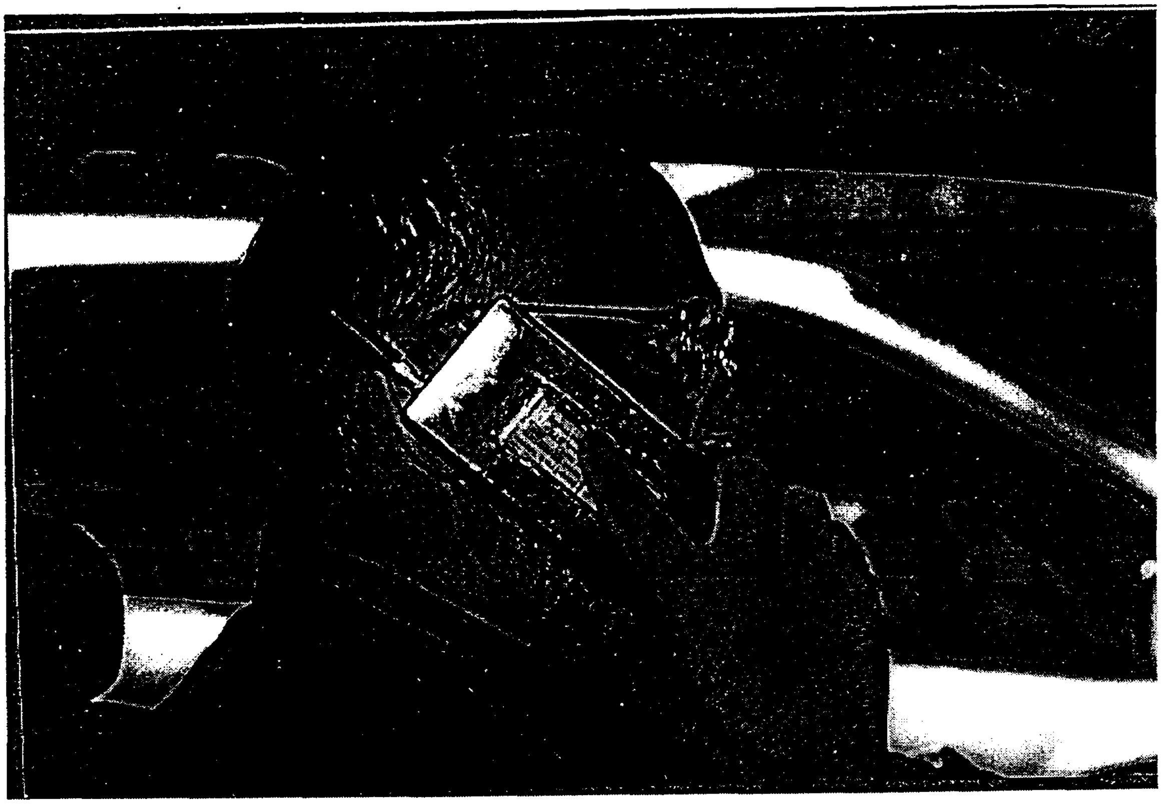


Figure 6. Test Configuration – Inside Car, Under Tree Test With Head Blockage

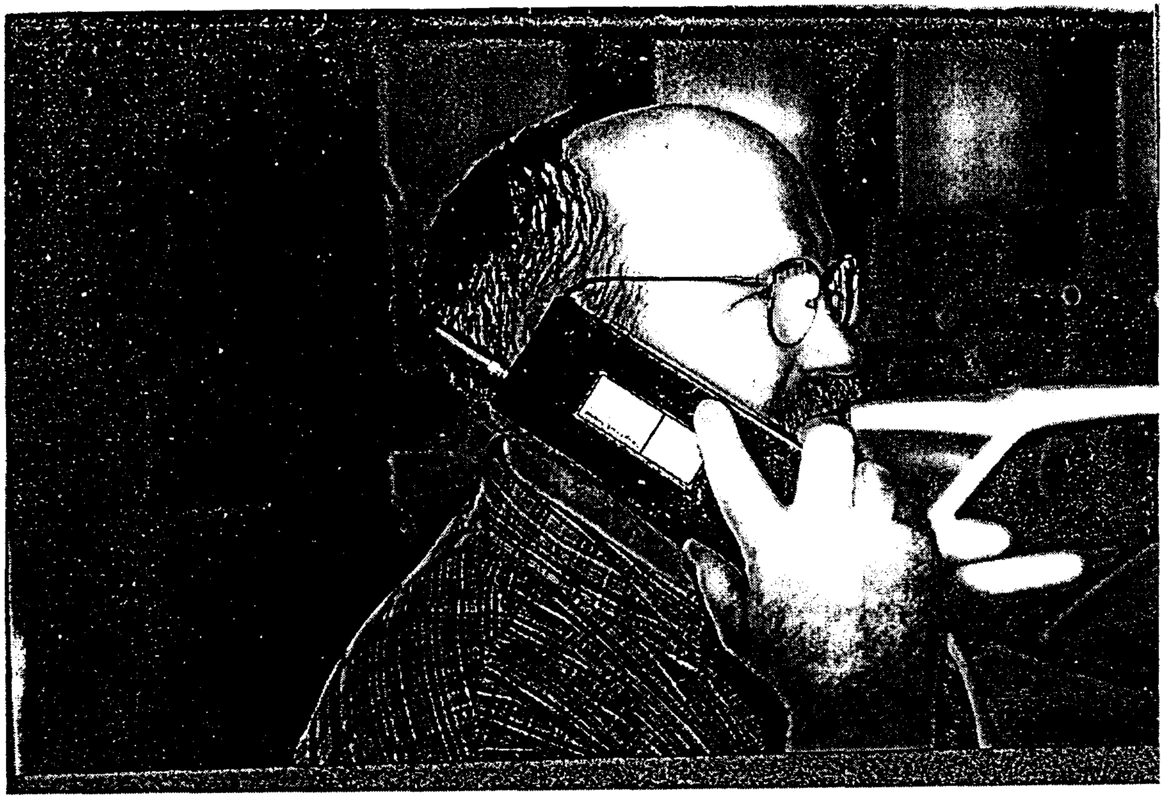


Figure 7. Test Configuration – Outside, Under Tree Test With Head Blockage

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The following press release was issued on February 8 at 7:31 a.m. EST.

FOR IMMEDIATE RELEASE CTIA '99, Booth #3125

QUALCOMM Contacts: Ed Knowlton, CDMA Technologies Marketing 1-(619) 651-7942 (ph) 1-(619) 658-1587 (fax) e-mail: eknowlton@qualcomm.com or Christine Trimble, Corporate Public Relations 1-(619) 651-3628 (ph) 1-(619) 651-2590 (fax) e-mail: ctrimble@qualcomm.com or Julie Cunningham, Investor Relations 1-(619) 658-4224 (ph) 1-(619)651-9303 (fax) e-mail: jcunningham@qualcomm.com

QUALCOMM Unveils New Semiconductor-Software Solutions to Support Next-Generation Wireless Devices

QUALCOMM CDMA Technologies Develops Further Integrated Chipsets, Software Solutions

NEW ORLEANS February 8, 1999 QUALCOMM Incorporated (NASDAQ: QCOM), pioneer and world leader of Code Division Multiple Access (CDMA) digital wireless technology, today presented its vision of future wireless telecommunication with technologies that will support the development of a new age of wireless devices and services. The company also announced it has shipped an industry-record, 100 million chips in total, to CDMA handset manufacturers worldwide.

The announcement marks the naming of QUALCOMM CDMA Technologies, formerly QUALCOMM's ASIC Products, the industry's leading semiconductor and software developer and provider. The name reflects the division's evolution from a hardware supplier to a strategic partner supplying a complete range of CDMA-based solutions.

New technologies include QUALCOMM's industry-leading sixth generation, single-chip Mobile Station Modem™ (MSM™) and a voice-recognition software product that provides speech-prompting and speech recognition functions. The division also introduced other supporting chipset solutions that will provide for the development of smaller CDMA handsets with greater power management and operating efficiency.

"The advanced products we've unveiled this week will enable a new future of opportunities for wireless telecommunications. They reflect our vision and commitment to challenge the conventional uses of technology, to dream of new applications and to drive development through close collaboration with our partners," said Don Schrock, president of QUALCOMM CDMA Technologies. "The dramatic consumer acceptance of CDMA-based networks services we've seen over the past five years will accelerate as we share with handset manufacturers our ideas for new applications of the technology."

New solutions presented by QUALCOMM CDMA Technologies at CTIA '99 include:

MSM3100 Baseband Processing Solution The MSM3100 solution is the sixth-generation Mobile Station Modem (MSM) and features: Packet-switched data speeds up to 86.4 kilobits per second (kbps); a 50 percent reduction in the printed circuit board area; and a 50 percent increase in stand-by time, to an estimated 300 hours in CDMA mode, using advanced power management. These unique features allow phone manufacturers the ability to innovate and differentiate their CDMA handsets while reducing development costs. The MSM3100 chip is the first baseband modem in the world to offer chip hardware support for advanced audio signal processing, location positioning using CDMA and Global Positioning System (GPS) technology and Universal Serial Bus (USB) providing manufacturers with a feature-rich, cost-effective and integrated solution.

PureVoice VR Voice Recognition Software QUALCOMM's PureVoice VR™ voice recognition software will allow manufacturers to quickly add powerful speech capabilities to CDMA handsets, benefiting consumers with easier hands-free use and access to complete voice dialing telephone directories. The PureVoice VR software is designed specifically for dual-mode cellular and PCS handset applications. It delivers speaker-dependent speech recognition, speaker-independent yes/no control words, voice memo and speech prompting.

Next-Generation MSM3100 Family Supporting Chipsets A new series of next-generation Radio Frequency (RF) and analog chips, the RFT3100™ and RFR3100™ processors, will achieve reductions in board area by as much as 50 percent and significantly lower power consumption for future handset models. Supporting the processors is the new PM1000™, a power management device developed to meet the demanding power requirements of CDMA handsets. The PM1000 device is a complete power management system, supporting the power regulation and battery charging functions. All of the chipsets will connect directly with the MSM3100 to form part of QUALCOMM's growing line of CDMA chips for subscriber applications.

QUALCOMM CDMA Technologies is the leading developer and supplier of CDMA chipsets, hardware and software solutions and tools with more than 30 million MSM chips shipped worldwide. The division supplies chipsets to the world's leading CDMA handset and infrastructure manufacturers including: ALPS ELECTRIC CO., LTD.; CASIO COMPUTER CO., LTD.; DENSO CORPORATION; FUJITSU LIMITED; Hitachi, Ltd.; Hyundai Electronics Industries Co., Ltd.; KYOCERA CORPORATION; LG Information and Communications, Ltd.; Samsung Electronics Ltd.; SANYO Electric Co., Ltd.; and Toshiba Corporation, among others.

QUALCOMM Incorporated (NASDAQ: QCOM) is a leader in developing and delivering innovative digital wireless communications products and services based on the Company's CDMA digital technology. The Company's major business areas include CDMA phones; integrated CDMA chipset and system software; wireless infrastructure; technology licensing; and satellite-based systems including OmniTRACS® and portions of the Globalstar™ system. QUALCOMM is headquartered in San Diego, Calif. QUALCOMM's fiscal 1998 revenues exceeded U.S. $3 billion. For more information, please visit the Company's web site at <http://www.qualcomm.com>.

Except for the historical information contained herein, this news release contains forward-looking statements that are subject to risks and uncertainties, including timely product development, the Company's ability to successfully manufacture significant quantities of CDMA or other equipment on a timely and profitable basis, and those related to performance guarantees, change in economic conditions of the various markets the Company serves, as well as the other risks detailed from time to time in the Company's SEC reports, including the report on Form 10-K for the year ended September 27, 1998, and most recent Form 10-Q.

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The following press release was issued on February 8 at 7:30 a.m. EST.

FOR IMMEDIATE RELEASE CTIA '99, Booth #3125

QUALCOMM Contacts: Ed Knowlton, CDMA Technologies Marketing 1-(619) 651-7942 (ph) 1-(619) 658-1587 (fax) e-mail: eknowlton@qualcomm.com or Christine Trimble, Corporate Public Relations 1-(619) 651-3628 (ph) 1-(619) 651-2590 (fax) e-mail: ctrimble@qualcomm.com or Julie Cunningham, Investor Relations 1-(619) 658-4224 (ph) 1-(619) 651-9303 (fax) e-mail: jcunningham@qualcomm.com

QUALCOMM Introduces Next-Generation CDMA RF and Analog Chipsets

Advanced CDMA RF Transmit and Receive System Solution Launched

NEW ORLEANS February 8, 1999 QUALCOMM Incorporated (NASDAQ: QCOM), pioneer and worldleader of Code Division Multiple Access (CDMA) digital wireless technology, today announced theintroduction of its next-generation series of Radio Frequency (RF) and analog chips. Components ofthe complete CDMA chipset solution for QUALCOMM's next generation MSM3100™ basebandprocessing chip include the RFT3100™ transmit (Tx) and RFR3100™ receive (Rx) processorsfeaturing unmatched savings in board area with significant reductions in power consumption overprevious generations. Also introduced today is the PM1000™ power management chip, whichprovides battery supervision and charging functions, programmable voltage regulation, andintegration of other collateral support functionality for CDMA handset applications.

The new chipsets will operate directly with QUALCOMM CDMA Technologies' newest MSM3100baseband processing solution and together form the most complete CDMA transmit/receive and powermanagement chipset solution to-date. Breakthrough new CDMA RF systems and process technology hasbeen applied to the development and enabled these new devices to provide unmatched area and powersavings. State of the art Silicon Germanium (SiGe) process technology is used to achieve superior RFreceiver performance and integration. The complete solution including the MSM3100 chipset andsoftware provides a highly efficient and fully compliant IS-95A or IS-95B CDMA handset solution.The RFT3100 and RFR3100 chipset is designed for transmit and receive compatibility with cellularas well as Personal Communications Service (PCS) frequency bands covering global CDMA markets.

"CDMA products based on the MSM 3100 series chipset solution, utilizing new technologies likeSiGe, will set the new standard of excellence for worldwide wireless subscriber equipment," saidJohan Lodenius, vice president of marketing for QUALCOMM CDMA Technologies. "This enableshandset manufacturers to design a new generation of significantly smaller and lighter multi-bandhandsets with very long standby times and rich data capabilities at lower production costs."

RFT3100 Transmit Processor The RFT3100 Baseband-to-RF Transmit Processor performs all transmit signal processingfunctions required between digital baseband and the power amplifier

(PA) for IS-95 CDMA cellularand PCS single-band and dual-band applications. It connects directly to the MSM3100 chip utilizingan analog baseband interface, which is upconverted to the cellular or PCS frequency bands with therequired output power to drive the PA.

The RFT3100 transmit processor offers the most advanced and integrated CDMA Transmit solutionavailable today, providing a printed circuit board area savings of more than 65 percent overprevious generation chipsets and optimized power savings for extended talk-time performance. Itincorporates the previous generation functionality of the IFT3000™ Baseband-to-IF Processortogether with the transmit processing of the QUALCOMM UD3000 IF to RF transmit converter all inan ultra small 32-pin bump chip carrier (BCC++) plastic package. The RFT3100 chip is fabricatedin an advanced BiCMOS process which enables both precision high-frequency analog circuits andlow-power CMOS functions.

RFR3100 Receive Processor The RFR3100 RF-to-IF Receive Processor offers the most advanced and integrated CDMA receivesolution designed to meet cascaded Noise Figure (NF) and Third-order Intercept Point (IIP3)requirements of IS-98 and JSTD-018 specifications for sensitivity, two-tone intermodulation, andsingle-tone desense. It performs all of the front-end receive (Rx) signal processing requiredbetween the antenna and the QUALCOMM IFR3000™ IF-to-Baseband Processor for IS-95 CDMAcellular and PCS single-band and dual-band applications. The RFR3100 processor integratesdual-band Low Noise Amplifiers (LNAs) and mixers for downconversion from RF to CDMA and FMIntermediate Frequency (IF), and together with the IFR3000 chip, comprise a completeRF-to-Baseband chipset solution for the Rx path. This device is fabricated on an advanced silicongermanium (SiGe) BiCMOS process which enables low-noise, high-linearity, high-frequency analogcircuits along with low-power CMOS functions, and will be available in a 32-pin BCC++ plasticpackage.

PM1000 Power Management Chip The PM1000 chip is a complete power management system device for CDMA mobile handsetapplications whose primary functions provide battery management and charger control as well aslinear voltage regulation with programmable voltages for digital and RF/analog circuits. The batterymanagement includes over-voltage and over-current protection, low battery alarm and accuratebattery gas gauge. The charger control includes fast charge and trickle charge modes for Lithium-Ion(Li-Ion) and Nickel Metal Hydride (NiMH) batteries. The voltage regulation includes power-on resetcontrol.

In addition to the power management functions, the PM1000 chip also contains a variety of collateralsupport functionality including a keyboard backlight driver, Liquid Crystal Display (LCD) backlightdriver, ringer/buzzer driver, a vibrator driver, support for electro-luminescent display driver, aReal Time Clock, and general purpose Analog-to-Digital Converter (ADC). All PM1000 operatingmodes and functionality can be controlled by the MSM3100's microprocessor through its three wireSerial Bus Interface (SBI). This chip will be available in a 64 plastic ball grid array (PBGA)package.

QUALCOMM will begin sample shipping the RFT3100, RFR3100, and PM1000 to customers in thethird quarter of 1999; production quantities are expected to be available in the fourth quarter of1999.

QUALCOMM CDMA Technologies is the leading developer and supplier of CDMA chipsets, hardware andsoftware solutions and tools with more than 30 million MSM chips shipped worldwide. The divisionsupplies chipsets to the world's leading CDMA handset and infrastructure manufacturers including:ALPS ELECTRIC CO., LTD.; CASIO COMPUTER CO., LTD.; DENSO CORPORATION; FUJITSU LIMITED;Hitachi, Ltd.; Hyundai Electronics Industries Co., Ltd.; KYOCERA CORPORATION; LG Information andCommunications, Ltd.; Samsung Electronics Ltd.; SANYO Electric Co., Ltd.; and Toshiba Corporation,among others.

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# # #

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FOR IMMEDIATE RELEASE CTIA '99, Booth #3125

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QUALCOMM Announces Sixth Generation CDMA Single-Chip Modem Solution

New CDMA Chipset Solution Provides a 50 Percent Reduction in Size While Increasing Standby Time to 300 Hours

NEW ORLEANS February 8, 1999 QUALCOMM Incorporated (NASDAQ: QCOM), pioneer and world leader of Code Division Multiple Access (CDMA) digital wireless technology, today announced the introduction of the MSM3100™, the company's sixth generation single-chip Mobile Station Modem™ (MSM™) baseband processing solution. This new generation chipset and system software solution features a 50 percent reduction in chip size and up to 300 hours of standby time.

"Our business is to work closely with the industry to define, develop and deliver on future needs for wireless communication," said Don Schrock, president of QUALCOMM's CDMA Technologies. "With the introduction of the sixth-generation MSM3100 chipset and software, we are taking our proven CDMA solutions to the next level of integration and cost savings while adding support for new high performance voice and data processing features. Combined with new tools and our world-class technical support staff, this ensures continued industry leading phone development times for our customers."

The MSM3100 chipset and software enable design of a new generation of CDMA handsets and data devices with rich feature sets and industry-leading performance. Higher on-chip integration now includes the addition of analog cores such as a 13-bit linear audio-codec, PLL, DAC's and ADC's. This facilitates a 50 percent size reduction of the printed circuit board area as well as a significantly reduced part count and lower bill-of-materials cost.

With new system software and hardware for enhanced system power control, stand-by times will also be approximately 50 percent higher than previous generation solutions. The MSM3100 chip incorporates advanced digital signal processing (DSP) functions, a Universal Serial Bus (USB) high speed data interface and support for additional CDMA Designer™ development tools. These enhancements allow phone manufacturers to further innovate and differentiate their CDMA handsets while reducing time-to-revenue.

New features include: Enhanced voice recognition, such as continuous digit dialing and support for large speaker independent libraries; and on-chip acoustic echo cancellation, eliminating the need for additional costly hardware in automotive, PC and other speaker phone applications. A Universal Serial Bus (USB) interface enables effective interconnection to desktop, laptop and Palm PC devices for much higher speed multimedia data transfers and software synchronization. The MSM3100 chip will also be the first baseband modem in the world to offer on-chip hardware support for in-phone Global Positioning System (GPS)-based CDMA position and location services which provides manufacturers with a cost-effective and integrated solution for the upcoming FCC mandate for emergency location tracking (E911).

"This is our most powerful chip to date," said Johan Lodenius, vice president of marketing for QUALCOMM's CDMA Technologies. "The MSM3100 solution provides a comprehensive set of advanced features with supporting tools as well as a robust and proven software package. This will enable CDMA handset manufactures to create a wide array of products with unprecedented functionality, form factors and operating performance."

Features of the MSM3100 Chip Include: ·

- QUALCOMM's newly developed integrated QDSP2000 digital signal processing (DSP) core, easily enables the additional performance requirement for advanced features such as voice recognition, GPS-based position location, speech compression, acoustic echo cancellation, noise suppression, and other audio enhancements. Acoustic echo cancellation support in the QDSP2000 core eliminates the need for DSP's in car-kits for additional cost savings. ·

- The QDSP2000 core features 40-bit computation units and datapaths, up to five operational executions in parallel, variable-length instructions to conserve program memory, and single-cycle instruction execution for computations. The powerful QDSP2000 consumes less power with better performance and only requires 8 Mips for Enhanced Variable Rate Coder (EVRC) execution, versus competitive digital signal processors requiring more than 20 Mips. A complete GUI-based software development toolkit for Sun and PC platforms is available for customized features. ·

- The integrated industry-standard ARM7 TDMI® microprocessor offering much higher performance with lower power consumption and smaller relative compiled-code size. The ARM7 is ideal for support of manufacturer application demands today as well as for the future. To facilitate software development the ARM peripherals have been customized by QUALCOMM to facilitate in-phone debugging capabilities of production handsets. ARM software tools are available directly from QUALCOMM to assist manufacturers with software development. ·

- Support for CDMA position location services utilizing GPS-based technology. This provides manufacturers with a cost effective and highly-integrated solution for the upcoming FCC E911 mandate. ·

- IS-95B compliant demodulator architecture, to support simultaneous demodulation of up to six or eight channels, depending on the rate-set used, for a maximum speed of 86.4 kilobits per second (kbps). ·

- Various analog cores are integrated onto the MSM3100 chip, reducing the number of handset components for substantial cost savings and reduction of PCB area. Included on the chip are: A 13-bit linear audio voice codec with Automatic Gain Control (AGC) function and integrated earphone amplifiers; PLL for support of various TCXO frequencies; on-chip voltage regulators for a single 2.5 volt (v) input interface that support internal chip voltages as low as 1.8 v; dual 8-bit transmit IQ DAC's which simplify the interface to the transmit Radio Frequency (RF) chain; and ADC's for battery and temperature monitoring. This level of integration enables shrinking of the printed circuit board by 50 percent for a very cost effective and low power design. ·

- A new enhanced sleep controller for both CDMA and AMPS modes will cut power consumption significantly in the MSM chip and for the entire phone. For example, an estimated 300 hours of stand-by time can be achieved in CDMA mode. ·

- Multiple serial interfaces including: Universal Asynchronous Receive Transmits (UARTs) for data communications as well as diagnostic monitoring; QUALCOMM developed Serial Bus Interface (SBI) for low speed control of RF and peripheral devices for power management; and USB for easy interconnection to a PC or car kit. With the greatly increasing popularity of USB in the PC marketplace, this interface is ideal for plug and play mobile phone connections to PC's and consumer appliances.

- An optimized system software solution which is fully compliant with dual-mode cellular and Personal Communications Service (PCS) band IS-95B specifications. The software includes a full suite of Internet protocols for fast development of data applications and ships fully tested and integrated into QUALCOMM's CDMA development tools for fast and flexible customer development.

QUALCOMM's MSM3100 chip interfaces directly with the IFR3000™ chip, the RFR3100™ and RFT3100™ chips, QUALCOMM's next generation fully integrated Intermediate Frequency (IF) chipset and the new PM1000™ power management chip.

System development software, verification, test, debug, calibration, manufacturing and field test support are available using the CDMA Designer development tools reducing time to market for a complete CDMA handset. Target applications include very small voice, high data rate and advanced user interface subscriber units for multi-mode cellular and PCS CDMA services.

The MSM3100 chip will be fabricated in a 0.18 um Leff process at 2.5V ± 10% in 0.8mm ball pitch 208-pin Fine Pitched Ball Grid Array (FBGA) package. For maximum current savings, the internal cores of the chip will operate down to 1.8 v. The 208-pin FBGA package is in a four-perimeter-rows-of-solder-balls (P4) configuration making circuit routing and assembly easier and enabling the use of cost effective printed circuit boards. Sample shipment to customers will begin in the third quarter of 1999 with production volumes starting by the end of the year.

QUALCOMM CDMA Technologies is the leading developer and supplier of CDMA chipsets, hardware and software solutions and tools with more than 30 million MSM chips shipped worldwide. The division supplies chipsets to the world's leading CDMA handset and infrastructure manufacturers including: ALPS ELECTRIC CO., LTD.; CASIO COMPUTER CO., LTD.; DENSO CORPORATION; FUJITSU LIMITED; Hitachi, Ltd.; Hyundai Electronics Industries Co., Ltd.; KYOCERA CORPORATION; LG Information and Communications, Ltd.; Samsung Electronics Ltd.; SANYO Electric Co., Ltd.; and Toshiba Corporation, among others.

QUALCOMM Incorporated (NASDAQ: QCOM) is a leader in developing and delivering innovative digital wireless communications products and services based on the Company's CDMA digital technology. The Company's major business areas include CDMA phones; integrated CDMA chipsets and system software; wireless infrastructure; technology licensing; and satellite-based systems including OmniTRACS® and portions of the Globalstar™ system. QUALCOMM is headquartered in San Diego, Calif. QUALCOMM's fiscal 1998 revenues exceeded U.S. $3 billion. For more information, please visit the Company's web site at <<http://www.qualcomm.com/>http://www.qualcomm.com>.

Except for the historical information contained herein, this news release contains forward-looking statements that are subject to risks and uncertainties, including timely product development, the Company's ability to successfully manufacture significant quantities of CDMA or other equipment on a timely and profitable basis, and those related to performance guarantees, change in economic conditions of the various markets the Company serves, as well as the other risks detailed from time to time in the Company's SEC reports, including the report on Form 10-K for the year ended September 27, 1998, and most recent Form 10-Q.

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